Numerically efficient direct solver-based full-wave model for EM scattering from complex-geometry particles

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Accurate and numerically efficient modeling of electromagnetic scattering from precipitation particles represents a crucial tool for a better analysis of weather radar/radiometer observations. In particular, the averaging of the scattering properties over different random orientations combined with a realistic complex geometry modeling, enables a better representation of the EM behavior of precipitation particle. In this context, the discrete dipole approximation (DDA) is one of the main approaches that has been used in the past as a geometry-flexible and numerically low-cost technique for computing scattering and absorption by snow particles. The open source code DDScat has been proven to be a numerically high efficient implementation of the DDA. However, since the code is based on iterative solvers, the major drawback of DDScat comes from the fact that if orientation averages are needed then computationally demanding linear equations must be solved repeatedly.

To overcome this limitation, we have chosen to apply a direct solver-based method, known as the characteristic basis function method (CBFM) [1], to the modeling of scattering by randomly oriented and complex-shaped snow particles, in a context of the Method of Moments (MoM) with a volumetric integral equation formulation. This domain decomposition technique is based on the generation of a new set of basis function adapted to the geometry of the scatterer, in order to significantly reduce the numerical size of the EM problem. This enables us to use a direct solver for the resolution of the final compressed system of linear equations, which is better adapted for multiple excitation problems. When applied to numerically medium snow particles, our CBFM based model for Coherent Scattering from Complex Hydrometeors (NESCoP) has been shown to yield good results [2], which compare well with those obtained with DDScat, while providing a significant gain in CPU time.

In this talk, we summarize the overview of NESCoP, prove its computational superiority over DDScat particularly for electrically large particles, and discuss how this work could help stimulate increased interest in solving problems involving larger complex-geometry particles, with higher number of orientations for a better understanding of the EM behavior of ice particles.

References

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[2] I. Fenni, Z. S. Haddad, H. Roussel, K. S. Kuo, and R. Mittra, 2017: A computationally efficient 3-D full-wave model for coherent EM scattering from complex-geometry hydrometeors based on MoM/CBFM-enhanced algorithm. *IEEE Trans. Geosci. Remote Sens.*, doi: 10.1109/TGRS.2017.2781625.

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